THE TOTEM ON-LINE RADIATION MONITORING SYSTEM

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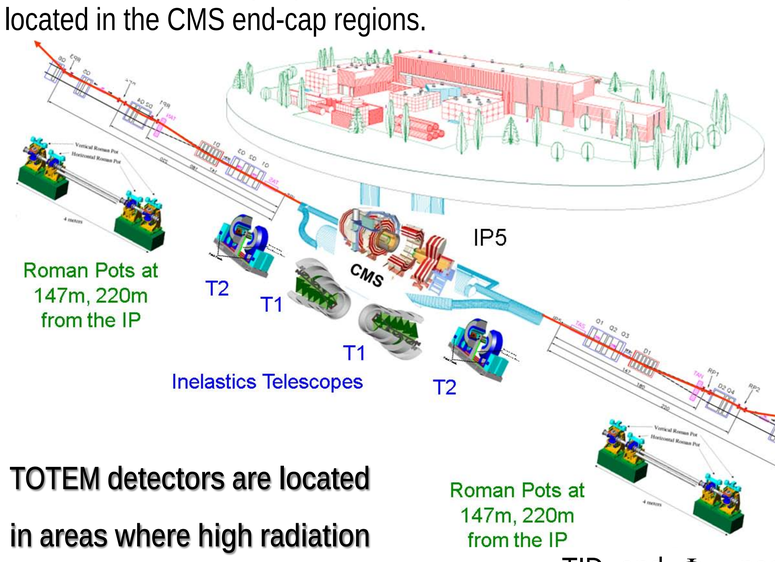
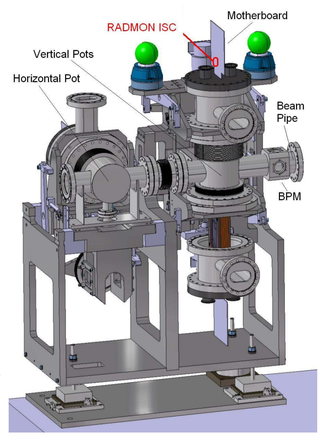
Introduction

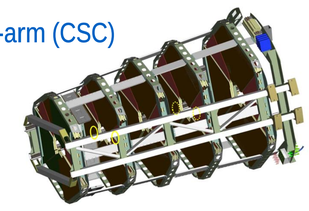
The TOTEM experiment consists of three sub-detectors: the Roman Pot (RP) Silicon Detectors, located in the LHC tunnel near the Interaction Point 5 (IP5) and two inelastic telescopes, T1 and T2, located in the CMS end-cap regions.



RP unit



T1 half-arm (CSC)



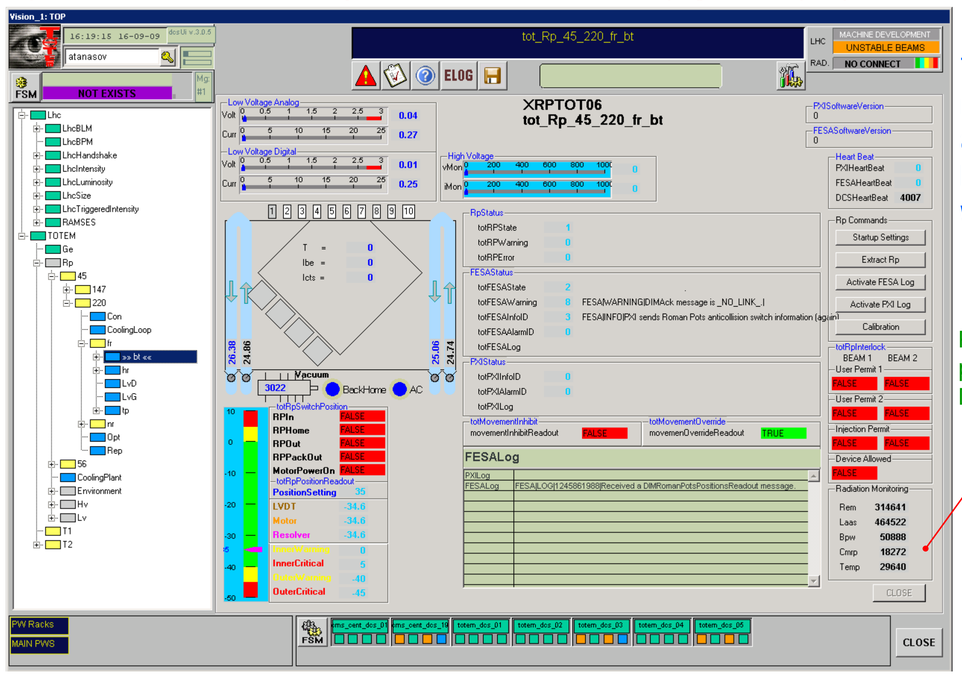
TOTEM detectors are located in areas where high radiation levels are expected

Detectors Locations	TID (kGy/year)	Φ_{eq} ($cm^{-2}\ y^{-1}$)
RP 147m Si Detectors	10	$> 1\times10^{13}$
RP 147m Motherboard	5	7.5×10^{12}
T1	15	1.5×10^{13}
T2	10	1.5×10^{15}

TID and Φ_{eq} needed to evaluate the radiation-induced changes in the detectors, to survey the radiation damage on the front-end electronics and to verify the Monte Carlo simulations. Moreover this system can help to detect anomalous increases of radiation levels that may arise from accidental radiation burst such as beam losses or unstable beams. This set of information can finally be used to better plan the TOTEM operation scenario.

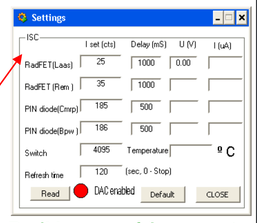
Control Software and System Performance

The layout of the ISC (unique RL for all sensors on-board) imposes a sequential readout of the RADMON sensors connected to the same ELMB. A control library has been developed in PVSS to drive the switches and loop over the sensors with different currents and powering times. In order to match with the readout requirements, the commands given to the hardware are sent over the CAN bus using SDO (Single Digital Objects) which allow sequential operations on demand. With the present version of the library the readout of one ELMB (e.g. 6 ISCs) is performed in about 1min.

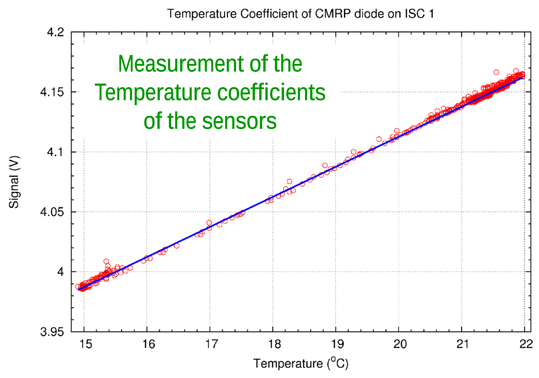


The control script runs in background and updates the PVSS *DataPoints* which are displayed in the user interface.

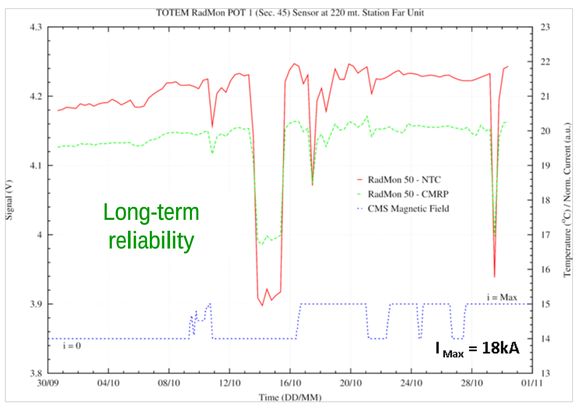
RadMon area in the user panel for RP Silicon Detectors

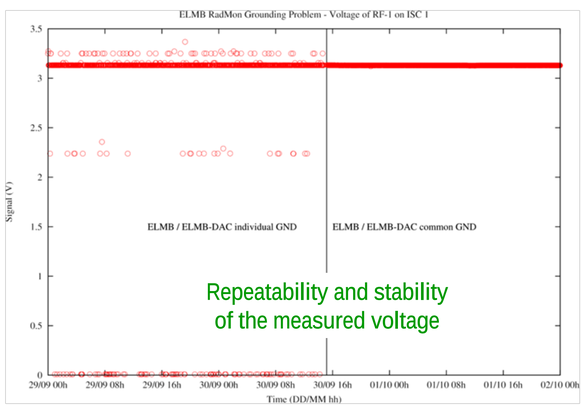


RadMon panel for experts



During the commissioning of the TOTEM RP Silicon Detectors installed in the LHC in 2009, it was possible to carry out a set of measurements to evaluate the system performance. These measurements, proved the reliability of the voltage measurements over the 300m signal lines that carry the RADMON signals from the RP Silicon Detectors to the ELMB system. The stability in the voltage readout has been determined to be better than 2mV.



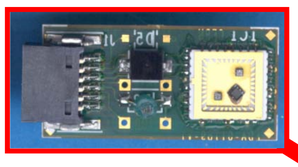


Hardware and System Layout

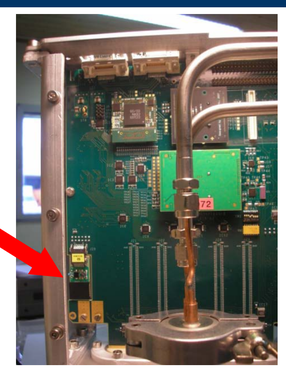
The basic unit of the RADMON system is the Integrated Sensor Carrier (ISC) that host radiation sensors connected to the readout electronics via long signal cables. The ISC PCB used in TOTEM is configured with 2 RadFET sensors for TID measurements, 2 *p-i-n* diodes to monitor the Φ_{eq} and 1 Temperature probe (NTC).

The different sensor types provide the required sensitivity and dynamic range to the system for its operation over the experiment lifetime.

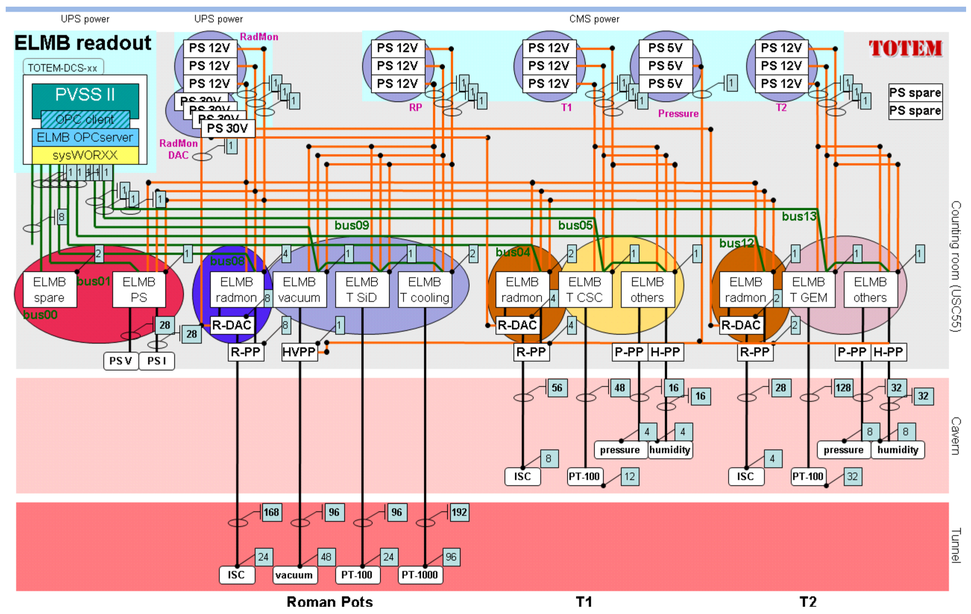
Integrated Sensor Carrier



- RadFET REM 501K
- RadFET LAAS 1600
- diode BPW34
- diode CMRP
- NTC 10kΩ
- common Return Line (RL)
- readout over 6-wires



RADMON ISC installed in a RP Motherboard

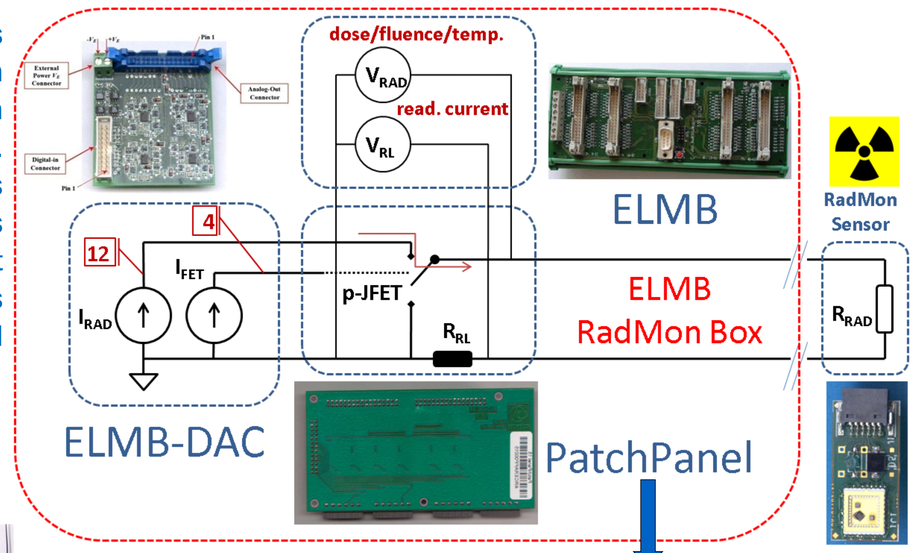


Each of the 24 RP Silicon Detectors is equipped with one RADMON ISC located on the RP Motherboard

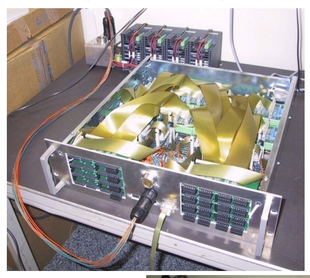
Other 12 ISCs are distributed over the T1 and T2 telescopes. For T1, the 8 ISCs are hosted in dedicated PCBs mounted on the CSC planes; while T2 is equipped with 4 ISCs located on the front-end PCB that read the signals from the GEM chambers.

The TOTEM RADMON read-out is based on Embedded Local Monitor Boards (ELMBs) and ELMB-DACs. This approach, already adopted and tested by the ATLAS experiment, simplifies the integration of the sensors in the DCS and makes it compatible with the existent JCOP DCS structure agreed by all LHC experiments. As shown in the Hardware Overview Diagram, the ELMB, communicates over the CAN bus with a PC of the DCS running the SCADA software (PVSS II). Each ELMB hosts 64 12-bit ADC channels (0-4.5 V). To power the RADMON sensors during the readout sequence, the 16 channels, 12-bit DAC-module allows the ELMB to drive currents. In the RADMON configuration, two ELMB-DAC boards can be connected simultaneously and controlled by one ELMB.

RadFETs and *p-i-n* diodes have to be readout with currents ranging between hundreds of μA and 1mA. The ELMB-DAC feeds current to the sensors and the voltage drop that generates between its contacts is measured with the ELMB.



INTEGRATION OF THE RADMON HW (1 PP = 3 ISC)



RadMon ELMB Box for RP Silicon Detectors

ELMB Box Front-Panel

Main features of the PP board :

- Since the range of the ELMB ADC is up to 4.5V, differential voltage attenuators (1:10) are used
- The NTC temperature sensor is directly connected to the 2.5V reference voltage output on the ELMB, in series with a 1MΩ resistor.
- To monitor the current flowing through each sensor being read out, the common Return Line (RL) is connected to ground over a 100Ω resistor. The small voltage drop on this resistor, is proportional to the current flowing on the RL
- During radiation exposure, the RADMON sensors must have the terminal shorted to ground. For this reason a series of switches (JFET transistors) on the PP board are opened by applying a voltage from DAC before starting the readout procedure. In the "normal close" position the JFETs short the sensor terminals.

References

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3. M. Huhtinen, presentations at the Collaboration Meetings, 2006; http://www.cern.ch/totem.
4. F. Ravotti et al., "Sensor Catalogue–Data compilation of solid-state sensors for radiation monitoring", TS-Note-2005-002, EDMS 590497, May 2005.
5. G. Kramberger, et al., "Design and Functional Specification of ATLAS Radiation Monitor", ATL-IC-ES-0017, ver.1.0, EDMS 498365, 2006.
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TOTEM RADMON Web Page: http://totem.web.cern.ch/Totem/work_dir/radmon/RadMon.html